GEL'PERIN, N.I.; KROKHIN, [redacted] ZELENETSKIY, N.N.

Studying the process of rectification at lowered pressures.
Trudy VNIISMDV no.2:127-129 '54. (MLRA 10:7)
(Plate towers) (Distillation, Fractional) (Vapor pressure)

KROKHIN, N.O.; ZELENETSKIY, N.N.

Studying the efficient operation of distillation apparatus.
Trudy VNIISNDV no.2:129-134 '54. (MLRA 10:7)
(Distillation apparatus)

GEL'PERIN, N.I.; KROKHIN, N.G.; FRUMKINA, N.S.

Studying the distillation of fatty-acid ethyl ester mixtures.
Trudy VNIISNDV no.2:134-138 '54. (MLRA 10:7)
(Distillation) (Fatty acids)

GEL'PERIN, N.I.; KROKHIN, N.G.; BOGACHEVA, K.I.; ZELENTSKIY, N.F.

Use of distillation for purifying coumarin production waste acetic acid. Trudy VNIISNDV no.2:138-139 '54. (MLRA 10:7)
(Acetic acid) (Distillation) (Coumarin)

GEL'PERIN, N.I.; KROKHIN, N.G.; BORISENKO, A.T.

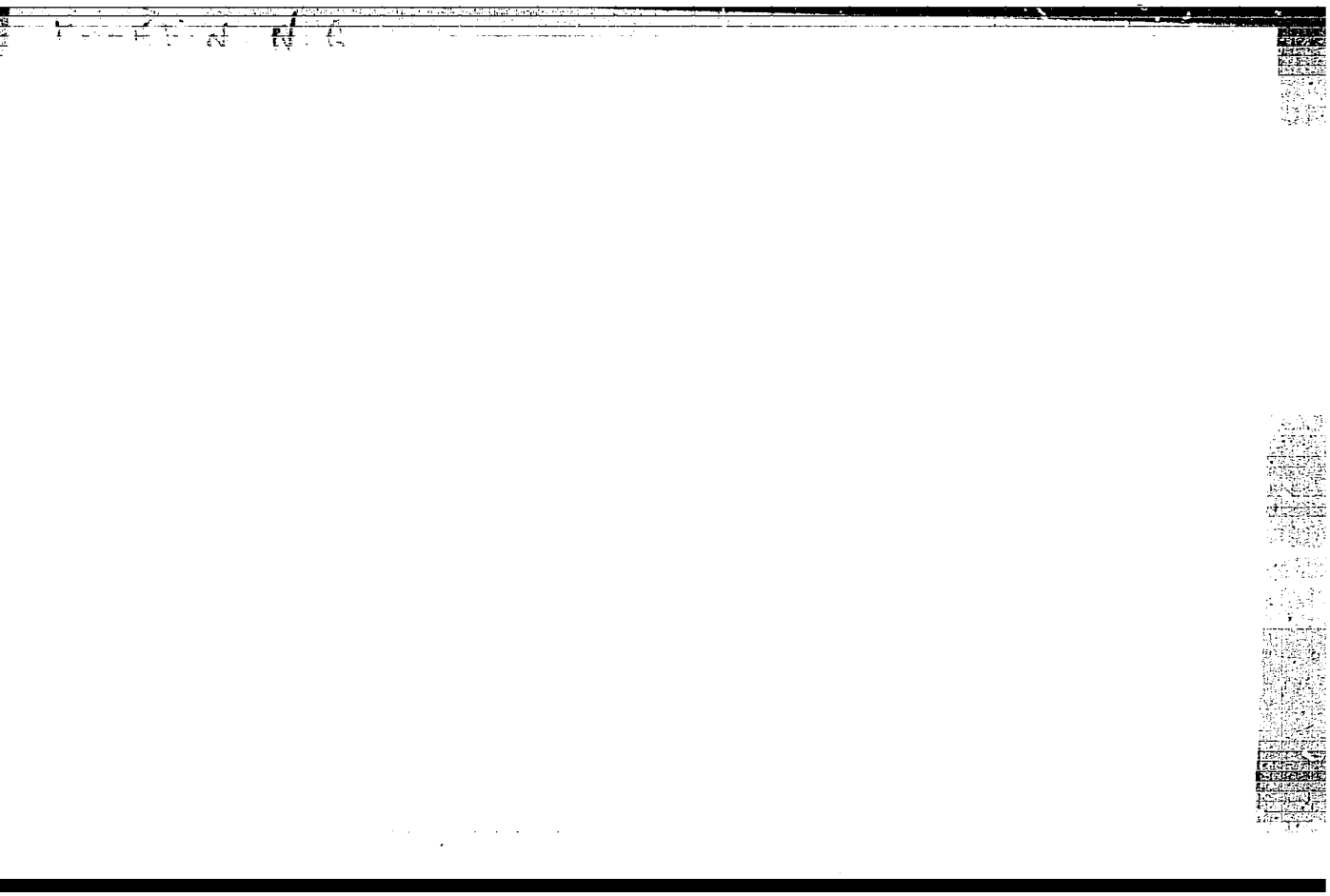
Distillation (cohobation) of eugenol aqueous solutions. Report No.1: Cohobation in cube apparatus. Trudy VNIISNDV no.2:141-146 '54. (MLRA 10:7)

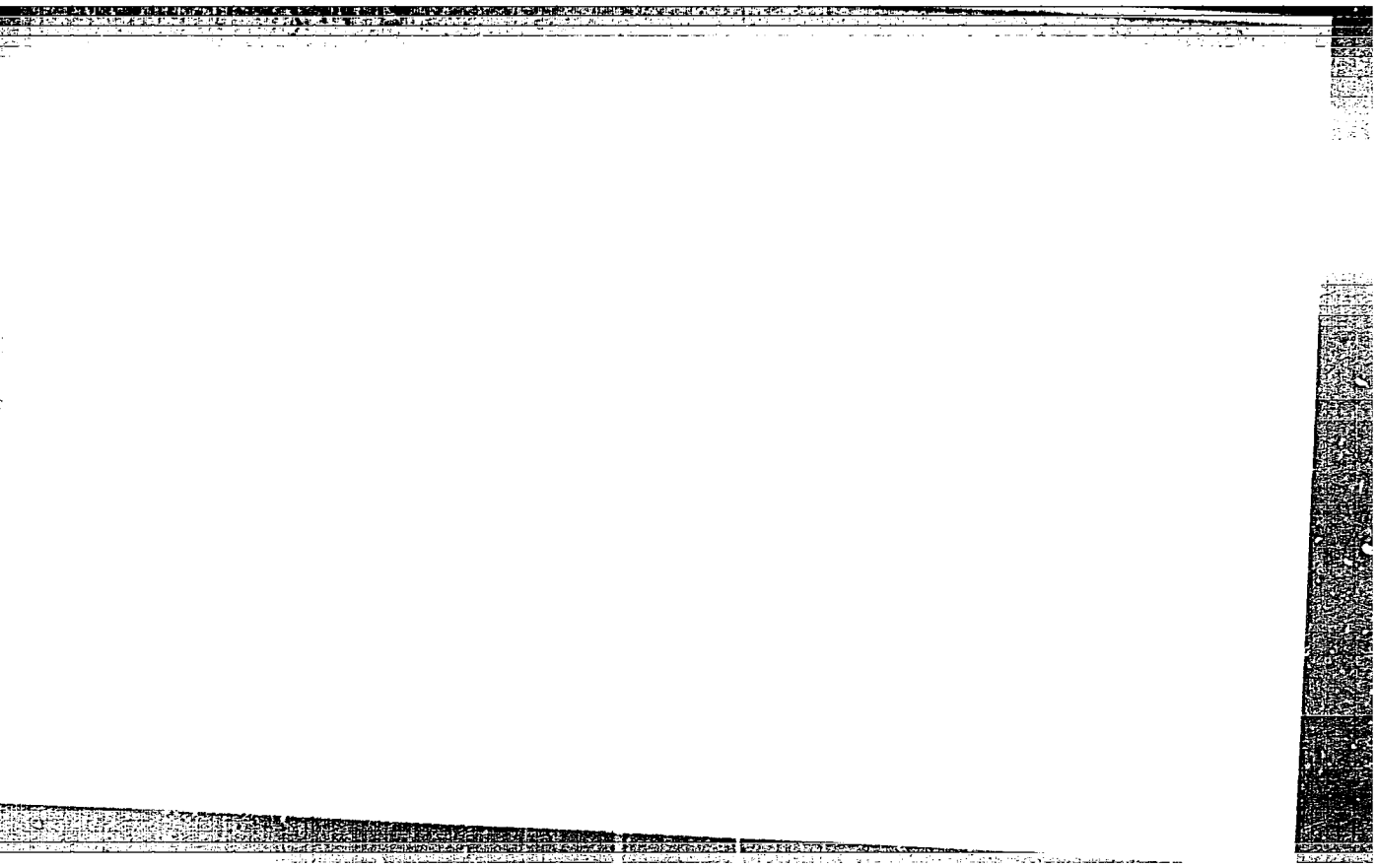
(Distillation) (Eugenol)

GEL'PERIN, N.I.; KROMIN, N.G.; BOGACHEVA, K.I.

Dehydration of chrome alum aqueous solutions (Utilization of the production by-products). Trudy VNIISNDV no.2:165-166 '54.
(MLRA 10:7)

(Alums)





APPROVED FOR RELEASE: 06/14/2000 CIA-RDP86-00513R000826620005-2"

GEL'PERIN, N.I.; KROKHIN, N.G.; KISELEVA, Ye.N.

Pilot plant testing of the method of continous extraction of vanillin in a spray tower. Trudy VNIISNDV no.4:151-154 '58.
(MIRA 12:5)

(Vanillin)
(Extraction (Chemistry))

KROKHIN, N.G.; ZELENETSKIY, N.N.

Best distillation procedure for perfume fractions of geranium and coriander oils. Trudy VNIISNDV no.4:181-185 '58. (MIRA 12:5)

(Essences and essential oils)
(Distillation, Fractional)

KROKHIN, N.G.; ZELENETSKIY, N.N.

Recovery of linaloöl from coriander oil and linalylacetate from clary sage oil by vacuum distillation. Trudy VNIISNDV no.4:185-189 '58. (MIRA 12:5)
(Essences and essential oils)
(Distillation, Fractional)
(Linaloöl)

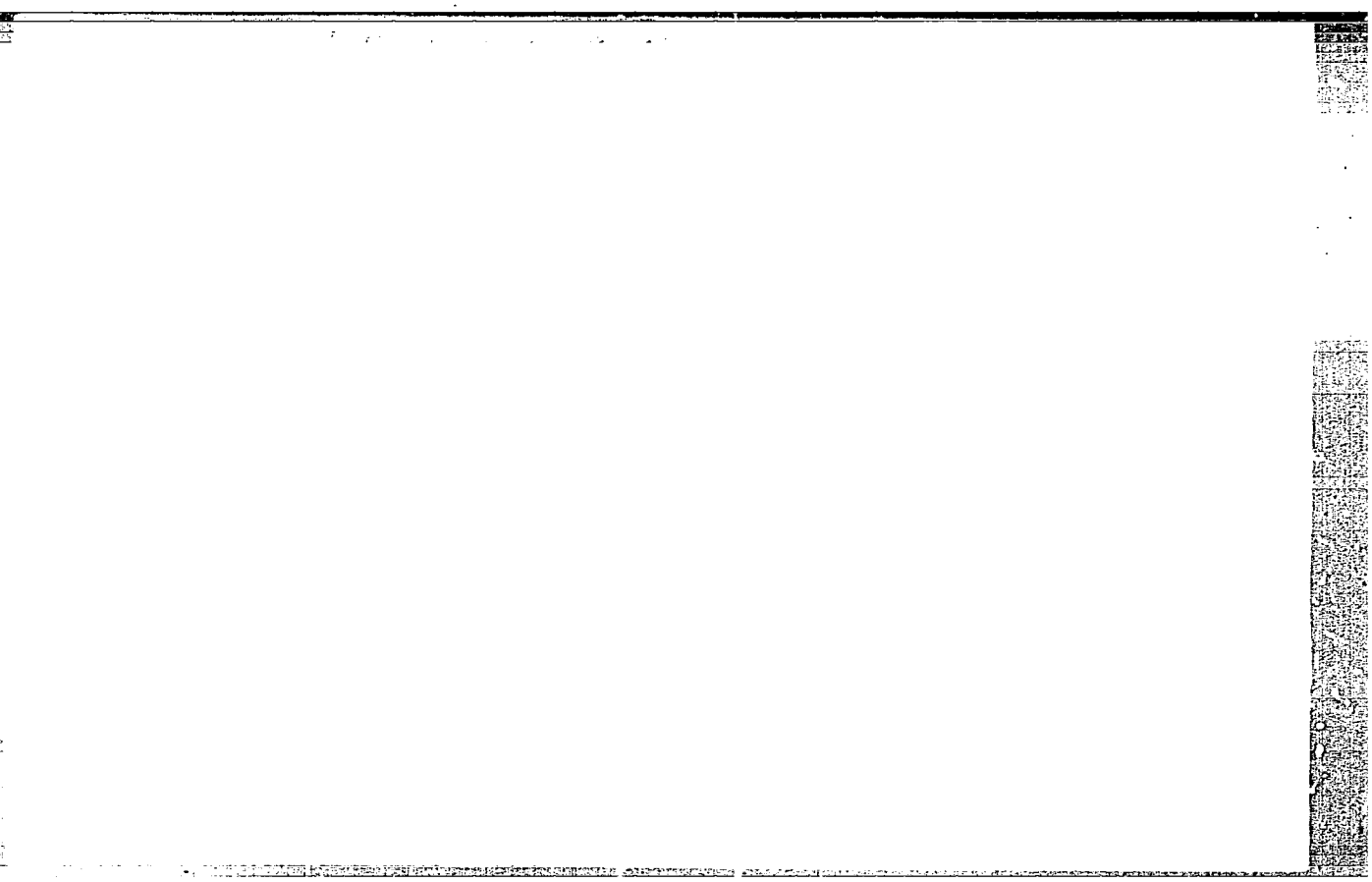
ORL'PERIN, N.I.; KROKHIN, N.G.; KISELEVA, Ye.N.

Extraction from solutions by condensing vapor phase extraction agents. Zhur. prikl. khim. 31 no.7:1026-1036 Jl '58. (MIRA 11:9)

1. Vsesoyuznyy nauchno-issledovatel'skiy institut sinteticheskikh i natural'nykh dushistykh veshchestv Ministerstva promyshlennosti prodovol'stvennykh tovarov SSSR.
(Extraction (Chemistry))

TOVBIN, Isaak Moiseyevich; FAYNBERG, Yevsey Yefimovich; BOROVOY, L.F., inzh., retsenzent; KROKHIN, N.G., kand.tekhn.nauk, spetsred.; HESH, G.S., red.; SOKOLOVA, I.A., tekhn.red.

[Technological designing for fat processing enterprises; refining and hydrogenation of fats] Tekhnologicheskoe proektirovanie zhiroperererabatyvaiushchikh predpriiatii; rafinatsiia i gidrogenizatsiia zhirov. Moskva, Pishchepromizdat, 1959. 398 p. (MIRA 12:6)
(Oils and fats)



APPROVED FOR RELEASE: 06/14/2000 CIA-RDP86-00513R000826620005-2"

Category : USSR/Theoretical Physics - Quantum Field Theory B-6

Abs Jour : Ref Zhur - Fizika, No 3, 1957, No 5703

Author : Borgstotskiy, V.B., Krokhin, O.N., Khlebnikov, A.K.
Title : Concerning the Radiation Correction to the μ-Meson Magnetic Moment.

Orig Pub : Zh. eksperim. i teor. fiziki, 1956, 30, No 4, 786-789

Abstract : The deviation from the Schwingor formula is calculated for the radiation correction to the magnetic moment under the assumption that the integration with respect to the momenta must be restricted to an upper limit λ_0, where $\hbar/\lambda_0 \sim 10^{-13}$ -- 10^{-14} cm, in connection with the results obtained by Landau and Pomeranchuk (Referat Zhur Fizika, 1956, 15733, 21813, 21814) concerning the inapplicability of the modern field theory to such distances. If this correction is written in the form $\Delta\mu/\mu = (\alpha/2\pi)(1 - \delta F)$, then $\delta F = (2/3)m\alpha/\lambda_0$, where m is the mass of the particle. For the μ-meson, the value of δF may turn out to be not too small.

Card : 1/1

S/056/60/038/03/31/033
B006/B014

24.7700

AUTHORS: Basov, N. G., Krokhin, O. N., Popov, Yu. M.

TITLE: Semiconductor Amplifiers and Generators Whose Carriers Have a Negative Effective Mass

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 38, No. 3, pp. 1001-1002

TEXT: Kroemar (Ref. 1) made the suggestion to use carriers with a negative effective mass in semiconductors for the amplification and generation of electromagnetic waves since negative losses will thus occur during the motion of carriers in the field. In order to produce such states it is advisable to use a constant electric field. In the present "Letter to the Editor" the authors demonstrate that it is impossible to produce states with negative losses by using a constant electric field. The condition $wf(\varepsilon_2)[1-f(\varepsilon_1)]n(\hbar\omega)-wf(\varepsilon_1)[1-f(\varepsilon_2)]n(\hbar\omega)=$ $= wn(\hbar\omega)\{f(\varepsilon_2)-f(\varepsilon_1)\} > 0$ must be satisfied for the energies $\varepsilon_2 > \varepsilon_1$ ($f(\cdot)$ is the electron distribution function, $n(\hbar\omega)$ is the number of

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photons of an energy $\hbar\omega = \varepsilon_2 - \varepsilon_1$, w is the probability of spontaneous emission). To obtain amplification, it was necessary that $\partial f(\varepsilon)/\partial\varepsilon > 0$, at least at some points of the range $\varepsilon_2 - \varepsilon_1$. This is nowhere the case if thermodynamic equilibrium is to be maintained. Direct calculations (Refs. 2-5) have shown that it is impossible to disturb thermodynamic equilibrium so strongly that $\partial f(\varepsilon)/\partial\varepsilon > 0$, if E = const, as was assumed by Kroemer. Also if in the case of anisotropic zones some components of the mass tensor are negative for certain values of the quasi-pulse, $\partial f/\partial\varepsilon > 0$ cannot be attained if E = const. This is due to the fact that in the case of semiconductors the interaction constant for acoustical and optical phonons is of the same order of magnitude. For a system of semiconductors with negative losses it is therefore necessary to obtain states with negative temperatures if $\partial f/\partial\varepsilon > 0$. There are 6 references, 3 of which are Soviet.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences, USSR)

82430

Semiconductor Amplifiers and Generators Whose Carriers Have a Negative Effective Mass

S/056/60/038/03/31/033
B006/B014

SUBMITTED: December 17, 1959

Card 3/3

83601

9.2570
24.7700

S/056/60/038/005/034/050
B006/B063

AUTHORS: Krokhin, O. N., Popov, Yu. M.

TITLE: Slowing-down Time of Non-equilibrium Carriers in Semiconductors

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 38, No. 5, pp. 1589-1592

TEXT: The determination of the slowing-down time of minority carriers is particularly important to the development of quantum-mechanical semiconductor generators and amplifiers. Negative losses in semiconductors may occur if the production time for negative temperatures in them (slowing-down time) is shorter than the lifetime of the produced external excitations of fast electrons and holes. The authors regard those electrons (holes) as minority (fast) carriers, the initial energy ε_0 of which is considerably higher than the mean thermal or degeneration energies (if the gas is degenerate), but not higher than the threshold energy of impact ionization of the valency band. In sufficiently pure crystals of regular shape, the slowing down of electrons is due to scattering by lattice vibrations. Impurities and defects need not be taken into account. The following

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B006/B063

Slowing-down Time of Non-equilibrium Carriers in Semiconductors

calculations, which are only made for electrons of the conduction band, hold analogously for the holes of the valency band. The calculations proceed from the equation of motion for the electron distribution function $f(\vec{p})$ in the crystal, taking the Fermi degeneracy of the electron gas into account. In order to investigate the slowing-down of electrons in the absence of an electric field and with $f(\vec{p}) \equiv f(\varepsilon)$, where ε is the electron energy ($\varepsilon = p^2/2m$), the authors first give expressions for $\partial f(\varepsilon)/\partial t$, the electron lattice collision time τ, the energy state density $Q(\varepsilon)$, and the variation of the mean electron energy in time dE/dt. By use of these relations they study the slowing down of a single electron without considering degeneracy. $f(\varepsilon)Q(\varepsilon) = \delta(\varepsilon - E)$ holds in this case. The case of an acoustic phonon is treated first. For the slowing-down time from E_o to E due to electron scatterings by acoustic lattice vibrations one obtains: $t = (2/a_o)(E^{-1/2}-E_o^{-1/2})$; $a_o = 2(2m)^{1/2}u^2/l_{ac}(T)kT$, where l_{ac} is the mean free path of the electron in scattering, u is the velocity of sound, and T is the lattice temperature. Next, the authors investigate the slowing down of a fast electron by optical lattice vibrations of a valence-type semiconductor. An expression is derived for t_{opt}. Furthermore,

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Slowing-down Time of Non-equilibrium Carriers in Semiconductors

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$t_{opt}/t_{ac} \approx 10^{-2}$ holds. In the following, degeneracy is taken into account and the slowing-down times are compared with one another, both regarding and disregarding degeneracy. It is found that the slowing-down time is not essentially influenced by taking degeneracy into account. N. G. Basov is thanked for discussions. B. I. Davydov and L. V. Keldysh are mentioned. There are 5 references: 3 Soviet, 1 US, and 1 British.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: December 17, 1959

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86932

S/056/60/039/005/051/051
B006/B077

24.7700 (1043,1143,1559)

AUTHORS: Basov, N. G., Krokhin, O. N., Popov, Yu. M.

TITLE: The Possibility of an Application of Indirect Transitions to Produce Negative Temperature in Semiconductors

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 5(11), pp. 1486 - 1487

TEXT: In some semiconductors, especially in germanium and silicon, the infrared emission and absorption edges correspond to the indirect transitions, that is during emission and absorption of a photon emission or absorption of a phonon takes place simultaneously. The long wave emission corresponds to simultaneous emission of photon+phonon on these transitions. In a sample with a low enough temperature where the phonons necessary for absorption are missing in the lattice, the emission with the longest wave will not be absorbed and here the sample will be practically transparent. If the carrier concentration is increased with

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The Possibility of an Application of Indirect Transitions to Produce Negative Temperature in Semiconductors

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respect to the equilibrial concentration by means of any mechanism (exposure, electric field etc.) then under certain conditions a negative temperature should occur with respect to the considered transitions. The conditions for such a process should be: $\omega_r/\omega_f < T_{eff}/T$, where ω_r and ω_f is the photon and phonon frequency, T the temperature of the sample and T_{eff} the effective temperature where the levels of the conduction band with respect to those of the valence band are filled. For germanium would hold $\omega_r/\omega_f \sim 25$ and thus $T_{eff}/T > 25$, which would be fulfilled for a sample at helium temperature if the excitation is brought about by a radiation source or an external electric field. There are 10 references: 1 Soviet, 8 US, 1 Czechoslovakian.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR)

SUBMITTED: October 3, 1960

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88459

24.2120 (1155, 1482) also 2114

S/056/60/039/006/051/063
B006/B063

AUTHORS: Basov, N. G., Krokhin, O. N.

TITLE: Conditions for Electron Excitation of Negative Temperature States in a Gas Mixture

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 6(12), pp. 1777-1780

TEXT: A study has been made of the conditions, under which negative temperatures may occur in a gas discharge of a binary gas mixture, in which the atoms have the same energy levels. Experimental and theoretical publications by Sanders, Javan, S. G. Rautian, I. I. Sobel'man, A. Ferkhman, S. Frish, V. K. Ablekov, M. S. Pesin, and I. L. Fabelinskiy are discussed in the introduction. Javan has shown that in a binary gas mixture, in which two energy levels of different atoms are very close to each other, excitation may pass from an atom of one gas to an atom of the other. This has a great influence on the distribution of excited states among the atoms. Following the results obtained by Javan, the authors have studied the case where the energy levels coincide, on the assumption that

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Conditions for Electron Excitation of Negative Temperature States in a Gas Mixture

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$T_e \gg T_a$. If the lifetime of an excited state were only dependent on collisions of second kind between electrons and atoms, the number of excited atoms would be given by $N_i = N_o \exp(-\varepsilon_i / kT_e)$, where ε_i is the excitation energy; N_o is the number of atoms in the ground state; and T_e is the electron temperature. On account of the conversion of excitation energy into kinetic energy and due to radiation processes, N_i is actually much smaller. This fact is considered by referring the temperature only to two levels $\varepsilon_i^a = \varepsilon_i^b$ of the atoms of the gases a and b. For such levels it may be assumed that the interaction cross section for the atoms has a resonance character. Consequently, the excitation transfer between atoms a and b is considerable. Such an interaction between ε_i^a and ε_i^b can lead to a leveling of temperature. If, for example, T_i^a is first greater than T_i^b, ε_i^a will be excited with a temperature $T_i^{a'} > T_i^a$, and a negative temperature is likely to occur between the level ε_i^a and a level $\varepsilon_k^a < \varepsilon_i^a$, whose temperature

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Conditions for Electron Excitation of Negative Temperature States in a Gas Mixture

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B006/B063

$T_k^a < (\varepsilon_i^a/\varepsilon_k^a)T_i^{a'}$. Several relations are derived for some details of these conditions. There are 1 figure and 6 references: 4 Soviet and 2 US.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev, Academy of Sciences USSR)

SUBMITTED: July 22, 1960

X

Card 3/3

6.3200 (2503, 2803)
6.3300 (2201, 2801, 2503)

85900
S/053/60/072/002/001/005
B006/B067

AUTHORS: Basov, N. G., Krokhin, O. N., and Popov, Yu. M.

TITLE: Generation, Intensification, and Detection of Infrared and Optical Radiation by Means of Quantum Systems

PERIODICAL: Uspekhi fizicheskikh nauk, 1960, Vol. 72, No. 2, pp. 161 - 209

TEXT: The present paper gives comprehensive survey of the theory, the possibilities of application, and the properties of molecular generators and intensifiers. In the introduction the authors discuss the sources of electromagnetic radiation which they divide into three groups (thermal source, luminescence source, and generators) and which differ above all by the width of the emission spectrum. They then discuss the principle of the generation and intensification of waves which is based on the induction of transitions in quantum systems (molecules, atoms, ions, etc.). Molecular generators, and paramagnetic intensifiers may be used for the generation and

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Generation, Intensification, and Detection of Infrared and Optical Radiation by Means of Quantum Systems

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B006/B067

intensification of submillimeter infrared and optical waves. To produce such generators and intensifiers it is necessary to obtain a system which is not in thermodynamic equilibrium (i.e. in a state with negative temperature). In such a state the occupation of the energy levels is bound to increase with increasing energy, and the system is bound to emit photons under the influence of a radiation impinging from outside. It may be used not only for the generation but also for the intensification of radiation. In spite of the spontaneous radiation such intensifiers are considerably sensitive in the infrared. It has already been suggested to use spectral lines of different materials for producing highly sensitive radiation indicators which are free from noises of spontaneous radiation. One of the most important characteristics of such a system with negative temperature is the "number of active particles", i.e., the particle excess on the upper levels compared with the lower ones which are generated per unit time. Another important characteristics is the quantity $K = 2\pi |d|^2 n / \hbar \Delta\omega$, where $|d|^2$ is the square of the matrix element

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Generation, Intensification, and Detection of Infrared and Optical Radiation by Means of Quantum Systems

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B006/B067

of the dipole moment between the levels concerned, n the number of the active particles, and $\Delta\omega$ the spectral line width. The quantity K enters the condition of the self-excitation of the generators and determines the intensification coefficient of the intensifier, as is shown in part 8. In molecular gases K is in the cm range only $1/10^3$ of the value it has in crystals of paramagnetic ions. Similar conditions prevail also in the infrared. Hence the use of solids seems to be the most promising. The present paper which gives a survey of published data and the results obtained in this field is presented in the following way: Chapter I: methods of obtaining states in systems with negative temperatures. The theory of negative temperatures; sorting of molecules by means of an inhomogeneous electric or magnetic field in molecular beams; the excitation of gas molecules by means of gas discharge; momentum method of producing negative temperatures in semiconductors; production of negative temperatures in semiconductors between levels lying within one conduction band ("amplifier with negative mass"); production of negative temperatures by the method

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of double resonance. Chapter II: Interaction between radiation and systems with negative temperature; conditions of self-excitation; theory and suggestions for the production of resonators and intensifiers; quantum indicators of radiation. Finally, it is pointed out that quantum systems are of great importance in the generation and intensification of electromagnetic cm and dm waves, especially for radio engineering. Increase in the frequency stability and considerable increase in the receiver sensitivity. With ammonia molecular generators already high frequency stability was attained. The noise temperature in this region is at about 10°K. Research in this field leads to a new branch of physics: quantum radiophysics. V. A. Fabrikant is mentioned. There are 23 figures and 80 references: 33 Soviet, 34 US, 3 Japanese, 7 Australian, 2 British, and 1 French.

Card 4/4

KROKHIN, O. N., POPOV, Yu. M., and BASOV, N. G.

"Negative Absorption Coefficient at Indirect Transitions in Semiconductors."

Report presented by N. G. Basov at the 2nd Intl. Conference on Quantum Electronics, 23-24 Mar 1961, Berkeley, California.

BASOV, N. G., POKOV, Yu. A. and KLOKHN, O. N.

"Negative Absorption Coefficient at Indirect Transitions in Semiconductors."

report presented at the Hungarian Symposium on Luminescence, Balatonvilagos, Hungary, 7-10 June 1961.

KROKHIN, O. N., LISITZYIN, L. N., MARKIN, E. P., OSIPOV, B. D., BASOV, N. G.

"On Negative Photoconductivity and the Induced Electron Transitions"

Paper presented at the IUPAP International Conference onPhotoconductivity, Ithaca, New York, 21-24 Aug. 1961.

P. N. Lebedev Institute of Physics, Academy of Sciences, USSR.

6.3300 (incl. 2605)
6.3000 (2105, 1106, 1138)

21319
S/030/61/000/003/004/013
B105/B215

AUTHORS: Basov, N.G., Krokhin, O.N., Popov, Yu.M.

TITLE: Generation of coherent light by means of solids

PERIODICAL: Vestnik Akademii nauk SSSR, no. 3, 1961, 61 - 66

TEXT: A short survey is given on methods of producing generators for optical and infrared radiations, in which quantum transitions among energy levels in solids, luminophores, and semiconductors are utilized. Infrared and optical generators are mentioned which are based upon the principle of induced radiation in quantum systems of negative temperatures (N.G. Basov, A.M. Prokhorov, 1954), highly coherent radiation sources of luminescent substances in infrared and optical spectral regions, exciting by strong optical radiation (T.G. Mayman, D.F. Nel'son, A.L. Shavlov, P.P. Sorokin, 1960). The production of such sources is closely related to the problems of interaction between radiation and substance, structures of the energy levels of the substances, probability of radiation and nonradiation processes. S.I. Vavilov contributed considerably to the solution of these problems. The action of permanent afterglow of organic luminophores which

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have been discovered by S.I. Vavilov and V.L. Levshin (1928) possibly is used for creating new sources of light. P.P. Feofilov (student of S.I. Vavilov) together with L.N. Galkin studied (1957) in detail absorption bands and emission of U^{+++} in calcium fluorite. Resonators are used to increase the interaction between radiation and substance of negative temperature (A.M. Prokhorov, 1958; A.L. Shavlov, 1958). Furthermore, a report is given on the generation of optical and infrared radiation by applying activators in corundum and calcium fluorite. The optical radiation source used was a corundum crystal (Al_2O_3) with of Cr_2O_3 impurities (0.05 per cent by weight). The wide absorption band of the transition level $^4A_2$ to $^4F_2$ corresponds to a wavelength of ~5600 A. Fig. 2 shows a schematic representation of the uranium ion level in the calcium fluorite crystal. Some methods of creating negative temperatures in semiconductors are recommended (N.G. Basov, B.M. Vul and Yu.M. Popov, 1958) for generating infrared and optical radiations by semiconductors. Negative temperatures of semiconductors can be reached by intrazonal electron-hole transitions, and by intrazonal transitions and transitions from the base region to the level of impurity atoms. So far, there exists no general

theory on the determination of the lifetime of nonequilibrium carriers in semiconductors. The difficulties arising in connection with high a high excitation energy, disappear when indirect transitions in germanium and silicon semiconductors are utilized (N.G. Basov, O.N. Krokhin, and Yu.M. Popov, 1960). The minimum energy in the conduction band of these semiconductors, and the maximum energy in the valence band correspond to different values of the quasi-momentum of the electron (Fig. 4). The longest long-wave radiations correspond to the transition of the electron from the minimum conduction band into the maximum valence band, and at the same time a phonon is emitted so that the sum of the energies of photon and phonon equals Δ. The width of the spontaneous radiation line in semiconductors equals kT. In semiconductors, a change in frequency by superposition of a magnetic field of $\sim 1.5 \cdot 10^{-20} \frac{H}{m}$ is possible due to the low effective carrier mass m. For germanium it is 10% of the radiation frequency of intrazonal transitions in fields of $H \sim 10^4$ Gauss. Probably it will soon be possible to develop generators of infrared and optical radiation which can be used in laboratories, and also in various fields of science and technology. There are 4 figures.

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29241 S/026/61/000/012/002/003
D037/D113

9,2574 (also 1158, 1055)

AUTHORS: Basov, N.G., Krokhin, O.N., and Popov, Yu.M.

TITLE: Generators and amplifiers of light

PERIODICAL: Priroda, no. 12, 1961, 16-25

TEXT: This article deals with the development of quantum radiophysics and the theory, development and application of generators of monochromatic, optical and infrared radiation. In 1952, a new principle of generating and amplifying electromagnetic radiation in quanta systems, based on induced radiation, was proposed by N.G. Basov and A.M. Prokhorov. In 1954-55, the first quantum generators of the electromagnetic waves of the centimeter band, based on induced radiation, were built. Quantum amplifiers of the centimeter and decimeter wavebands, used for increasing the sensitivity of receiving equipment and proposed for the first time in 1956 by N. Blumbergen, are based on the 3-level system studied by N.G. Basov and A.M. Prokhorov. Optical generators, based on the same principles, were proposed for the first time in the USSR in 1957-58 by Basov, Prokhorov, B.M. Vul and Yu.M. Popov. It is stated that world-wide attempts are being made to use quantum systems

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Generators and amplifiers of light

for the creation and development of generators and amplifiers in the meter and ultraviolet wavebands and possibly also in shorter wavebands. The authors give a very general explanation of resonance absorption, induced and spontaneous radiation, and quanta systems working with "negative temperature". They point out the need to develop devices ensuring the possibility of obtaining monochromatic radiation with the aid of media of finite dimensions, suggesting in this connection the use of a system of parallel mirrors. In radiowave generators, the parallel mirrors are replaced by a resonator which can concentrate all radiation energy on one type of oscillation, thus ensuring high-directivity radiation and monochromatization. Discussing generators of optical and infrared radiation, the authors describe two types of generators, one of them using a mixture of helium (pressure 1 mm Hg) and neon (0.1 mm Hg) excited by low-temperature discharge and enclosed in a quartz envelope. In the second type, spectral radiation lines of various solids, mainly monocrystals excited by intensive optical radiation, are used. The monocrystal of a synthetic ruby has latterly been replaced by uranium and samarium ions in calcium fluorite. Semiconductors, used instead of luminescent crystals in optical and infrared radiation generators, also give very good results: accomplishment of electrical excitation methods, high density

Generators and amplifiers of light

of the excited centers, and the possibility of changing the generation rate in the magnetic field. In the high light concentrations of optical waveband generators, the light pressure may be up to 1 million at. and may be used for studying the properties of substances on strong electrical fields, acceleration of charged particles, acceleration of chemical reactions and exact processing of various materials. Soviet scientist V.A. Fabrikant is mentioned in connection with research work in this field. There are 8 figures and 2 Soviet-bloc references.

ASSOCATION: Fizicheskiy institut im. P.N. Lebedeva AN SSSR(Moskva)
(Physics Institute im. P.N. Lebedev of the AS USSR(Moscow))

4X

Card 3/3

BASOV, N.G.; KROKHIN, O.N.; POPOV, Yu.M.

Using indirect transitions in semiconductors for determining states with negative absorption coefficients. Zhur. eksp. i teor. fiz. 40 no.4:1203-1209 Ap '61. (MIRA 14:7)

1. Fizicheskiy institut imeni P.N.Lebedeva AN SSSR.
(Semiconductors) (Quantum mechanics)

25208

S/056/61/040/006/029/031
B125/B202

9,4300

AUTHORS: Basov, N. G., Krokhin, O. N., Popov, Yu. M.

TITLE: Production of states with negative temperature in the p-n-junctions of degenerate semiconductors

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1879-1880

TEXT: When applying a voltage in forward direction of a p-n-junction in a semiconductor the concentration of the minority carriers increases near the p-n junction. The maximum concentration of these carriers corresponds to the complete compensation of the potential barrier by an external field. It corresponds almost to that part of the crystal where the carriers are majority carriers. (In this case the p-n junction is regarded as a sharp junction). The negative temperature in the band-to-band transitions occurs only when the Fermi quasi-levels corresponding to the non-equilibrium concentrations of the electrons and holes satisfy the condition: $\mu_e + \mu_p > \Delta$ (1). In this case μ_e and μ_p denote the Fermi

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Production of states with negative ...

"quasi-levels" of the electrons and holes, and Δ the width of the forbidden band. When applying a voltage in forward direction to a p-n junction the carriers must be degenerate at least in one part of the p-n junction. Semiconductors with such p-n junctions proved to be tunnel diodes, the mechanism of the occurrence of these states with negative temperature studied here does not correspond to the tunnel part but to the volt-ampere part of the characteristics of the tunnel diode. In the p-n junctions of the strongly degenerate semiconductors a state with negative temperature occurs before the potential barrier is completely compensated. Therefore, the dispersion theory of a current passing through a p-n junction can be used for qualitative estimations. The minimum value of the external voltage U_{min} at which a state with negative energy still occurs, is $U_{min} = \Delta/e$ where e is the charge of the electron. The order of magnitude of the current density is $I \sim -(eDn_p/L)\exp(eU/kT)$ where D denotes the diffusion coefficient, L the diffusion length, and n_p the electron density in the p-range of the semiconductor. The current density decreases with increasing degeneracy and also with decreasing

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temperature of the sample. For this reason a state with negative energy may be attained under steady operation. The spatial region in which a state with negative temperature occurs, is formed in the layer near the p-n junction with a density of the order of magnitude of one diffusion length. The high densities of the majority carriers surrounding the range of negative temperatures in the degenerate semiconductors can be used as radiation-reflecting surface, i.e., as resonator. The current density can be reduced if the semiconductors forming a p-n junction have different widths of the forbidden bands. For the observation of a negative temperature it is recommended to study the change of the volt-ampere characteristics on irradiation of the junction with the light of the corresponding frequency. There are 4 references: 3 Soviet-bloc and 1 non-Soviet-bloc. The two references to English-language publications read as follows: L. Esaki, Phys.Rev., 109, 603, 1958; J.I.Pankove, Phys.Rev.Lett., 4, 20, 1960.

ASSOCIATION: Fizicheskiy institut im. P.N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P.N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: April 18, 1960

Card 3/3

28767
S/056/61/041/003/020/020
B113/B102

9.4177 (1136)

AUTHORS: Basov, N. G., Krokhin, O. N., Lisitsyn, L. M., Markin, Ye.P., Osipov, B. D.

TITLE: Negative conductivity in induced transitions

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 3(9), 1961, 988-989

TEXT: In indirect transitions the carrier concentration at which a negative temperature occurs relative to the band-to-band transition, is comparatively small. It is by some orders of magnitude lower than the concentration at which a negative absorption coefficient exists for photons with an energy that is comparable with the width of the forbidden band. For the existence of a negative absorption coefficient it is necessary that the probability of induced photon emission in the band-to-band transition considerably exceeds the photon absorption probability in the inverse process in order to compensate also absorption in inner transitions. The processes, however, that are connected with internal absorption practically do not influence conductivity since they do not change the

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Negative conductivity in induced...

total number of free carriers. The band-to-band transitions which are in a state with negative temperature and which were induced by photon irradiation, reduce the number of free carriers and lead to a decrease in conductivity. Hence, the semiconductor which is in a state with negative temperature relative to the band-to-band transition is bound to have negative photoconductivity when irradiated with photons, whose energy is almost equal to the width of the forbidden band. The measurement of the spectral dependence of the semiconductor photoconductivity permits the determination of the states with negative temperatures also with lacking negative absorption coefficient. The authors made experiments for the production and observation of states with negative temperature in silicon. The specimen was irradiated at 4°K with light of a wavelength smaller than 0.7 μ which considerably increased its conductivity. Upon additional irradiation with weak monochromatic light a conductivity reduction (negative photoconductivity) was observed for a series of specimens in a narrow band of wavelengths near 1.1 μ. It can be assumed that the conductivity decrease observed is due to the existence of a state with negative temperature. However, also other explanations, such as impurity photoconductivity, are possible. [Abstracter's note: Essentially

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Negative conductivity in induced...

complete translation.] There are 3 Soviet references.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: July 13, 1961

Card 3/3

27483
S/053/61/075/001/001/003
B125/B108

9.3582 1538,1057

AUTHORS: Basov, N. G., Krokhin, O. N., Orayevskiy, A. N., Strakhovskiy, G. M., Chikhachev, B. M.

TITLE: Investigation of relativistic effects with the aid of molecular and atomic frequency standards

PERIODICAL: Uspekhi fizicheskikh nauk, v. 75, no. 1, 1961, 3 - 59

TEXT: The present paper gives a survey of experiments verifying the general theory of relativity, some problems in special relativity theory, and cosmological hypotheses by means of molecular and atomic frequency standards. V. L. Ginzburg (UFN, 59, 11 (1956); sb. "Eynshteyn i sovremennaya fizika", M., Gostekhizdat, 1956, str. 93 - 139) made suggestions for the experimental verification of general relativity theory. By means of cesium frequency standards with two separate resonators, an absolute frequency stability of $\pm 1.5 \cdot 10^{-10}$ was attained. A further improvement of the stability of cesium standards requires the use of narrower spectral lines. With slow molecule beams, an absolute stability

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of up to 10^{-12} was reached. A certain increase of stability may be attained using a beam of thallium atoms instead of cesium. Up to now, however, the authors have no information on such use of thallium. The electrical resonance method, i. e., the use of spectral lines of a molecular beam caused by transitions between rotational levels, guarantees the same stability as in cesium standards. The frequency standards relying on spectral lines of monatomic alkaline metals permit very sensitive indications. Quartz resonators, too, give a stability of 10^{-10} and, when immersed in liquid helium, even of 10^{-11}. The power of molecular generators has to be amplified by means of a low-noise amplifier (e. g., JBB(LBV)) and an amplifying klystron. Self-tuning is necessary for high-precision frequency measurements. In measurements of the gravitational frequency shift by means of molecular generators on board of artificial satellites, the influence of the first order Doppler effect has to be eliminated. This can be done, for instance, by an exact measurement of long time intervals on the Earth and on the satellite with subsequent comparison by radiocommunication. Another method of this kind is based on the mixing of a signal emitted from the Earth (frequency f) with the signal

of a molecular generator on the satellite (frequency 2f). Ionospheric and tropospheric fluctuations have to be taken into account. Measurements of the gravitational shift of frequency are being prepared (Sci. News Lett., 76, 35 (July 18, 1959)). The gravitational shift may be measured from two points of different altitude on the Earth's surface (mountain) without the use of satellites and, therefore, without consideration of the Doppler effect of first and second order. For H = 3.2 km and $f = 10^{10}$ cps, $\Delta f = 3.4 \cdot 10^{-3}$ cps. At present, two first-order experiments are known for the verification of special relativity theory. In one of them (proposed by Møller and carried out by Townes), two inversely directed beams of excited ammonia molecules were sent toward each other through the horizontal resonators of two molecular generators mounted on a rotatable plate. The expected frequency deviations were not found in these experiments. The other first-order experiment with respect to (v/c) is based on the measurement of the phase difference of two nonsynchronized molecular generators placed on a rotatable base at a distance of a few meters. Some cosmological effects may be verified experimentally by means of highly stable atomic clocks. An idea of V. A. Fok (G. M. Strakhovskiy, Doklad na Lomonosovskikh chteniyakh v MGU, 1958) concerning singular reference

systems is mentioned. The variations of the gravitational constant ($\delta g = g.10^{-10}$ within a year, according to Dirac) can be verified by comparing the motion of a high-precision atomic clock with the revolution period of an Earth satellite. The eccentricity of the Earth's orbit may also have an influence on the gravitational constant. The hypothetical time dependence $\delta\alpha/\alpha \sim 10^{-2}\,\delta g/g$ of the fine structure constant α (L. D. Landau et al., DAN SSSR, 95, 497, 773, 1177 (1954)) can be verified experimentally by comparing the motion of two atomic clocks of different types. The character of gravitation may be determined by another series of experiments. There are 31 figures and 113 references: 47 Soviet and 66 non-Soviet. The three most recent references to English-language publications read as follows: Missiles and Rockets, No. 1, 1961, p. 34; B. Hoffmann, Phys. Rev. 121, 337 (1961); S. M. Bergmann, J. Appl. Phys. 31, 275 (1960).

L 11085-63
AT/IJP(C) EEC(b)-2/EWT(1)/EWG(k)/BDS--AFFTC/ASD/ESD-3--Pz-4--

ACCESSION NR: AT3002986 S/2927/62/000/000/0093/0095

AUTHOR: Basov, N. G.; Krokhin, O. N.; Popov, Yu. M. 64

TITLE: State with negative temperature in p-n transitions of degenerate semiconductors

SOURCE: Elektronno-dyrochnyye perekhody v poluprovodnikakh. Tashkent, Izd-vo AN UzSSR, 1962, 93-95

TOPIC TAGS: semiconductor negative temperature, population inversion, semiconductor interband transition, negative absorption coefficient

ABSTRACT: Population inversion with respect to interband transitions is possible only if at least one type of carrier is degenerate. Since transitions of this type are referred to the diffusive portion of the volt-ampere characteristic, negative temperature can be expected in a region, near the p-n transition, whose thickness is of the order of the diffusion length. Although cryogenic treatment can produce a population inversion at any value of current density, however small, a comparatively high nonequilibrium concentration of minority carriers is necessary to bring the value of the

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ACCESSION NR: AT3002986 0.

negative absorption coefficient close to unity. The authors compute that a current density of 10 amp/cm^2 is required in order to achieve a density of the injected minority carriers of 10^{15} cm^{-3}, assuming a diffusion coefficient of 10 cm^2/sec and carrier lifetime of 10^{-10} sec.

ASSOCIATION: none

SUBMITTED: 00 DATE ACQ: 15May63. ENCL: 00

SUB CODE: GE NO REF SOV: 002 OTHER: 001

mcs/wm
Card 2/2

36488
S/181/62/004/003/044/045
B101/B102

24,2600

AUTHOR: Krokhin, O. N.

TITLE: Negative absorption through indirect exciton recombination in semiconductors

PERIODICAL: Fizika tverdogo tela, v. 4, no. 3, 1962, 822 - 825

TEXT: It was demonstrated that at low temperatures the radiative recombination from exciton states is more probable than the recombination of free carriers. In that way negative absorption can occur at a relatively low exciton concentration. The total radiation intensity at slight deviations from equilibrium concentration is:

$$dI_c + dI_{ex} = (n'/\tau)(\hbar d\omega/kT)e^{-x}\left\{x^2/2 + (2y^{1/2}/\pi^{3/2}R^3)(\nu_{eff}/n_{eff}p_{eff}\right\} \quad (7).$$

Here dI_c is the radiation intensity due to free carrier recombination; dI_{ex} is the number of quanta emitted per unit volume per unit time in the spectrum range ω to $\omega+d\omega$ in indirect exciton recombination; $n' = p'$ is the carrier concentration in excess of equilibrium; τ is the carrier lifetime referred to indirect recombination; $y = (\hbar\omega + \varepsilon - \Delta + u)/kT$ wherein ε is the

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phonon energy; Δ is the minimum forbidden-band width; u is the exciton binding energy ($u > 0$); R is the exciton radius; $\nu_{eff} = (m_{ex}kT/2\pi\hbar^2)^{3/2}$; $n_{eff} = 2(m_e kT/2\pi\hbar^2)^{3/2}$; $p_{eff} = 2(m_h kT/2\pi\hbar^2)^{3/2}$ where m_{ex}, m_e, m_h denote the masses of the exciton, electron, and hole, respectively. Negative absorption occurs when the induced radiation, equal to $n_r dI_{ex}$ (n_r is the number of quanta in the given oscillator), becomes greater than the absorption by free carriers and excitons which is equal to $Nc(\sigma\nu+\sigma_e n+\sigma_h p)dt$; σ is the absorption cross section, N the number of quanta, and c the velocity of light. From a discussion of Eq. (7) it follows that a negative coefficient of absorption can occur in indirect exciton recombination in semiconductors at a departure from equilibrium concentration that is much less than in recombination of free carriers. There are 5 references: 4 Soviet-bloc and 1 non-Soviet-bloc. The reference to the English-language publication reads as follows: W. P. Dumke, Phys. Rev., 105, 139, 1957.

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Negative absorption through... S/181/62/004/003/044/045
B101/B102

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR, Moskva (Physics Institute imeni P. N. Lebedev of the AS USSR, Moscow)

SUBMITTED: January 2, 1962

Card 3/3

BASOV, N. G.; KROKHIN, O. N.; POPOV, J. M. [Popov, Yu. M.]

Negative absorption coefficient at indirect transitions in semiconductors. Acta phys Hung 14 no.2 3:231-240 '62.

1. P. N. Lebedev Physical Institute of the Academy of Sciences USSR, Moscow, USSR. Presented by G. Szigeti [Gyorgy Szigeti]

BASOV, N.G.; KROHIN, O.N. [Krokhin, O.N.]; ORAEVSKI, A.N. [Orayevskiy, A.N.]; STRAHOVSKI, G.M. [Strakhovskiy, G.M.]; CIHACIEV, B.M. [Chikhachev, B.M.]

Possibility of studying relativistic effects with the aid of the molecular and atomic standards of frequency. Analele [illegible]t 16 no.2:83-146 Ap-Je '62.

L 14972-63 EWA(k)/EWP(k)/EWG(k)/EWT(1)/BDS/EWA/EEC(b)-2/EZ(t)-2
AFFTC/ASD/ESD-3/RADC/AFGC/AFWL Pf-4/Pz-4/P1-4 GG/AT/WG/JHB/K/EH/IJP(C)
ACCESSION NR: AP3005363 S/0181/63/005/008/2384/2386

85
84

AUTHOR: Basov, N. G.; Krokhin, O. N.

TITLE: Transformation of strong monochromatic radiation into electric current

SOURCE: Fizika tverdogo tela, v. 5, no. 8, 1963, 2384-2386

TOPIC TAGS: semiconductor laser, light-to-electricity conversion, light-to-current converter, inhomogeneous semiconductor laser, light transducer, laser detector

ABSTRACT: It is shown that strong monochromatic radiation can be converted into electric current in an inhomogeneous p-i-n semiconductor with strongly degenerate p and n regions. Space-coherent monochromatic radiation is focused on the semiconductor, producing electron-hole pairs. In this case the chemical potential in the electron region of the semiconductor (ζ_e) will coincide with the Fermi quasi-level of electrons in the i region (μ_e), and the chemical potential in the hole region (ζ_p) will coincide with the Fermi quasi-level of the holes in the i region (μ_p). Recombination current can be made small if

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$$\zeta_e - \mu_e - (\mu_p - E_v) > kT \text{ and } \zeta_p - \mu_p - (\mu_e - E_c) > kT,$$

where E_c and E_v are energies corresponding to the edge of the electron and hole zone, respectively, and T is the temperature of the sample. These conditions require strong degeneracy of the n and p regions. The potential difference across the sample will then be $\hbar\omega/e$. When current is produced, the absorption factor is a function of the current and the number of quanta absorbed per unit time becomes $\int RdV + (I/e)$, where I is the current and V the volume in which recombination occurs. The expression RdV includes recombination in the i region as well as the recombination current. The efficiency factor η, i.e., the ratio of the power at the load R_n to absorbed power equals

$$\eta = \frac{I^2 R_n}{\hbar\omega\left(\int RdV + I/e\right)}.$$

For large values of η to be obtained, two conditions must prevail: $I > e\int RdV$ and $R_n > R_i$, where R_i is the internal resistance of the device (mainly of the i

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ACCESSION NR: AP3005363

region). The efficiency can approach unity. Strongly doped regions form a waveguide along which the radiation is propagated. Dimensions of the i region should be selected so as to ensure full absorption of the radiation. Another possibility lies in the utilization of the coherence of the emission to create an optical oscillator analogous to a semiconductor oscillator.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR, Moscow (Physics Institute, AN SSSR)

SUBMITTED: 26Apr62 DATE ACQ: 06Sep63 ENCL: 00

SUB CODE: PH NO REF SOV: 002 OTHER: 003

Card 3/3

KROKHIN, O.N.

Problems in the generation of optical radiation. Vest. AN S.SSR 33 no.8:62-69 Ag '63. (MIRA 16:8)
(Lasers)

ZHARKOV, G.F.; KROKHIN, O.N.

Summer schools of physics in France and Italy. Vest. AN SSSR 33 no.11:111-113 N '63. (MIRA 17:1)

KROKHIN, O.N.

Optical quantum generators using semiconductors. Priroda 51 [i.e. 52] no.5:90-91 '63. (MIRA 16:6)

1. Fizicheskiy institut im. P.N. Lebedeva, Moskva.
(Lasers)

L 11280-63 EWA(k)/EWT(1)/FBD/BDS/T-2/3W2/EEC(b)-2/ES(t)-2--AFFTC/ASD/ESD-3/RADC/APGC/AFWL--Pl-4/Po-4--JHB/IJP(C)/WG/K/EH

ACCESSION NR: AP3000510 S/0020/63/150/002/0275/0278 94/86

AUTHOR: Bugayev, V. S.; Basov, N. G. (Corresponding Member, AN SSSR); Bul, B. M. (Corresponding Member, AN SSSR); Kopy*lovskiy, B. D.; Krokhin, O. N.; Markin, E. P.; Khvoshchev, A. N.; Shotov, A. P.

TITLE: Semiconductor quantum oscillator based on the p-n transition in GaAs 35 21

SOURCE: AN SSSR Doklady, v. 150, no. 2, 1963, 275-278

TOPIC TAGS: laser, gallium arsenide laser, infrared

ABSTRACT: Coherent emission has been obtained from p-n transitions on GaAs at 77K. The current pulse length was less than 3 μsec and had a repetition frequency of 50 pps. Threshold current density was about 10^4 amp/cm². Crystal specimens were prepared by diffusing impurities into strongly doped GaAs to secure a sufficiently flat and optically homogeneous p-n transition with an area of 10^{-3} cm². Two surfaces perpendicular to the transition plane were given optical flats and a high reflection coefficient. The width of the narrowed line beyond the emission threshold was 1 to 5 Å. The sharp narrowing of the line testified to the establishment of cavity feedback and commencement of oscillation. The brightness of the crystal, observed through an infrared

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ACCESSION NR: AP3000510

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microscope, sharply increased upon crossing the threshold; the bright region of the crystal was 10 to 15 μ wide. Two photos of the bright regions are given, corresponding to injection currents of 10 and 18 a. Increasing current density reduced the width of the emitting regions, apparently because of the stimulated recombination processes occurring in an area of shorter initial diffusion length. Some specimens manifested simultaneous emission from two transitions in parallel planes spaced 30 μ apart. "The authors express their thanks to L. Ya. Krol' for placing the monocrystals of gallium arsenide at their disposal, Yu. N. Kopolev, N. N. Borzunov, L. N. Novak, and Yu. P. Zakharov for their help with the work, and to V. I. Maly*shev and A. M. Leontovich for a wealth of valuable advice." Orig. art. has: 13 formulas and 3 figures.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute, AN SSSR)

SUBMITTED: 11Feb63 DATE ACQ: 12Jun63 ENCL: 00

SUB CODE: PH NO REF SOV: 007 OTHER: 003

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Card 2/2

BASOV, N.G.; KROKHIN, O.N.

Conversion of intensive monochromatic radiation into electric current. Fiz. tver. tela 5 no.8:2384-2386 Ag '63. (MIRA 16:9)

1. Fizicheskiy institut im. P.N.Lebedeva AN SSSR, Moskva.
(Radiation) (Electric currents)

KHOKHLOV, O. N.

"Plasma heating by laser radiation."

report presented at the Intl Symp on Laser Physics & Applications, Berne, 12-14 Oct 64.

Inst Physics im P.N. Lebedev, AS USSR, Moscow.

KROKHIN, V. N.

"Plasma heating by laser radiation."

report presented at the Intl Symp on Laser Physics and Applications, Bern, 12-14 Oct 64.

P N Lebedev Physical Inst, AS USSR, Moscow.

ACCESSION NR: AP4036408 S/0030/64/000/004/0158/0160

AUTHOR: Krokhin, O. N.

TITLE: Investigations in quantum radiophysics (scientific session)

SOURCE: AN SSSR. Vestnik, no. 4, 1964, 158-160

TOPIC TAGS: laser, laser conference, laser research, semiconductor laser, gas laser, ruby laser, Raman laser

ABSTRACT: A scientific session on quantum radiophysics was held 11-12 December 1963 under the auspices of the Department of General and Applied Physics at the Institute of Physics im. P. N. Lebedev. The reports dealt mainly with the state of research in quantum radiophysics, with particular attention given to lasers and their application. A. M. Prokhovov presented an introductory report on general principles and problems of quantum radiophysics in the microwave, optical, and other ranges. He pointed out that in the microwave range the employment of maser generators and amplifiers has been very successful. Because of their frequency stability, masers can be

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ACCESSION NR: AP4036408

utilized as frequency standards. In the optical range lasers make it possible to obtain a luminous energy in excess of several hundreds of joules in a comparatively long pulse (10^{-3} sec) or a high power up to 10^{8}—10^{9} w in a short pulse (10^{-8}—10^{-9} sec), so that by focusing the radiation the electric fields may have an intensity of up to 10^{8} v/cm. Ionization of atoms, dissociation of molecules, and destruction of crystal lattices are possible in such fields. Some of these phenomena were observed experimentally. Yu. M. Popov presented a report on semiconductor lasers based on a p-n transition operating in both pulsed and continuous modes with high efficiency (higher than 60%) but with a stability of radiation frequency of only 10^{-4} — 10^{-5} in absolute units. A number of currently available semiconductor lasers are based on gallium and indium arsenide, indium phosphide, and the gallium arsenide-phosphide solid solution. A. N. Orayevskiy presented a report on gas lasers. These generators possess great monochromaticity and frequency stability (up to 10^{-14} in absolute units) and small beam divergence. I. I. Sobel'man discussed lasers based on Raman scattering, used for observing the forced Raman effect and for the generation of coherent radiation. The Raman laser based

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on Stokes lines does not require population inversion to achieve negative absorption. A similar situation occurs in the case of indirect transitions in semiconductors. The forced Raman effect is considered very suitable as the basis of wideband laser amplifiers pumped by sources of broad spectral composition. A. M. Bonch-Bruyevich, A. L. Mikaelyan, and N. D. Devyatkov presented a series of reports dealing with concrete types of lasers. B. K. Vaynshteyn reported on laser crystals. The reports of M. P. Vanyukov and A. M. Leontovich dealt with various modes of oscillations arising in lasers. Nonlinear effects, the generation of secondary and higher harmonics, superposition of radiation frequencies, phase modulation, and parametric generation were considered. Yu. L. Kokurin discussed the ranging of the Moon with the aid of a ruby laser mounted in the focus of a telescope at the Crimean Astrophysical Observatory. G. A. Askar'yan reviewed a number of works dealing with the investigation of plasma and the interaction between monochromatic luminous radiation and molecules. L. N. Kurbatov discussed the application of stable lasers for measuring low velocities with the aid of the Doppler effect.

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ACCESSION NR: AP4036408

ASSOCIATION: none

SUBMITTED: 00 DATE ACQ: 20May64 ENCL: 00

SUB CODE: PH NO REF SOV: 000 OTHER: 000

Card 4/4

ACCESSION NR: AP4042011 S/0057/64/034/007/1324/1327

AUTHOR: Krokhin, O. N.

TITLE: Self-consistent mode of plasma heating by laser emission

SOURCE: Zhurnal tekhnicheskoy fiziki, v. 34, no. 7, 1964, 1324-1327

TOPIC TAGS: plasma heating, laser plasma heating, laser, controlled thermonuclear reaction, controlled fusion reaction

ABSTRACT: Basov and Krokhin (Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 46, 1964, 171) have previously analyzed conditions under which 10^9-watt laser emission can heat high-density plasma to a temperature of 10^6—10^7 K. Energy transfer was assumed to be accomplished by a short powerful pulse focused on the plasma surface. The present paper treats a different case wherein the heated volume has initially a near-zero plasma density which then rises due to evaporation of material from the containing walls. In this manner, laser emission is effectively converted into heat during the entire process. The feasibility of this concept is shown by proving that, under certain conditions, the product of the absorption coefficient

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ACCESSION NR: AP4042011

and the linear dimensions of the system is constant and close to unity during all stages of heating. These conditions can be realized by focusing the laser emission into a narrow and sufficiently long conical cavity so that material is vaporized from the inner conical surface. The author proves the theoretical principle by considering a one-dimensional problem of heating plasma confined between two parallel planes. The far plane represents the vaporized surface. The analysis concludes that 4/7 of the total laser emission energy is spent to heat plasma and 3/7 to vaporize and create plasma. The process is limited by emission power; the pulse length must be less than the plasma dispersion time but more than the density equalization time. Thus, if $t \sim 10^{-8}$ sec, $Q < 10^{6}$ w for a system length of 10^{-2} cm, and $Q < 10^{10}$ w for a system length of 10^{-1} cm. The laser pulse heating of plasma can be used to make a pulsed source of neutrons generated in thermonuclear reactions. Orig. art. has: 15 formulas.

ASSOCIATION: Fizicheskiy institut imeni Lebedeva AN SSSR
(Physics Institute, AN SSSR)

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ACCESSION NR: AP4042011

SUBMITTED: 05Jul63 ATD PRESS: 3062 ENCL: 00

SUB CODE: EC, ME SOV: 002 OTHER: 000

Card 3/3

ACCESSION NR: AP4012541 S/0056/64/046/001/0171/0175

AUTHORS: Basov, N. G.; Krokhin, O. N.

TITLE: Conditions for heating a plasma by radiation from a laser

SOURCE: Zhurnal eksper. i teoret. fiz., v. 46, no. 1, 1964, 171-175

TOPIC TAGS: plasma, plasma heating, pulsed heating, pulsed plasma heating, laser plasma heating, optical radiation absorption, optical radiation absorption coefficient, plasma thermal conductivity, electronic thermal conductivity, gas dynamic plasma expansion

ABSTRACT: The feasibility is examined of using a laser to heat a deuterium plasma with ion density of the order of 3×10^{21} cm^{-3} at a temperature close to 10^7 deg. The optical radiation absorption coefficient is calculated to be approximately 10^2 cm^{-1}, showing that effective absorption occurs up to high plasma temperatures. It is shown that at the plasma temperature the energy loss in the plasma is due essentially to electronic thermal conductivity and amounts to 1.3×10^{17} erg/sec. Allowance for the gas dynamic expansion of the plasma also calls for additional laser power. It is concluded

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that a laser power of 10^9 W with flash duration of 10^{-8} sec is capable of heating a hydrogen plasma to somewhat below 10^7 deg, although the practical realization depends essentially on the progress in laser development. "The authors are deeply grateful to L. A. Artsimovich and V. I. Kogan for a discussion of the results of the work." Orig. art. has: 11 formulas.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva AN SSSR (Physics Institute, AN SSSR)

SUBMITTED: 28Nov62 DATE ACQ: 26Feb64 ENCL: 00

SUB CODE: PH NO REF SOV: 005 OTHER: 006

Card 2/2

ACCESSION NR: AP4031193 S/0056/64/046/004/1508/1510

AUTHOR: Basov, N. G.; Krokhin, O. N.

TITLE: Optical excitation of semiconductors

SOURCE: Zh. eksper. i teor. fiz., v. 46, no. 4, 1964, 1508-1510

TOPIC TAGS: laser, semiconductor laser, monochromatic radiation, coherent radiation, recombination radiation, optical pumping, optical excitation, resonant cavity

ABSTRACT: Excitation of semiconductors by monochromatic radiation with a frequency slightly higher than that of the edge of the intrinsic absorption band is investigated theoretically. A battery of independent p-n junction lasers is suggested as the excitation source of incoherent monochromatic radiation. It is pointed out that when the intensity of incident radiation is high, the sum $\mu_e + \mu_p$ of Fermi quasi-levels for electrons and holes approaches the energy of incident photons $\hbar\omega_1$. For some frequency band such that $\hbar\omega < \mu_e + \mu_p$, population inversion is achieved and oscillation may become possible. An expression for

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ACCESSION NR: AP4031193

the minimum intensity of incident radiation J_{min} necessary to reach the threshold for $\mu_e + \mu_p$ corresponding to the oscillation threshold is derived. It is shown that when oscillation occurs $\mu_e + \mu_p$ remains constant for a wide range of $J > J_{min}$. At a very high intensity of radiation ($J \gg J_{min}$), when considerable heating of electron-hole gas takes place, the system becomes a highly efficient converter of incoherent into coherent radiation, with efficiency approaching 100%.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute, Academy of Sciences, SSSR)

SUBMITTED: 17Feb64 DATE ACQ: 07May64 ENCL: 00

SUB CODE: PH NO REF SOV: 005 OTHER: 002

Card 2/2

ZUYEV, V.S.; KROKHIN, O.N.

Two conferences on lasers and their uses held in London and in Geneva. Vest. AN SSSR 35 no.4:80 Ap '65.
(MIRA 18:6)

KARLOV, N.V.; KROKHIN, O.N.

The physics Nobel Prize for 1964. Usp. fiz. nauk 85 no.2:387-389 F '65. (MIRA 18:3)

L [illegible] EWA(k)/EWG/EWT(1)/EWG(k)-2/T/EWA(m)-2/EWA(h) IJP(c) WG/AT

ACC NR: AP5015833 SOURCE CODE: UR/0030/65/000/006/0101/0102

AUTHOR: Krokhin, O. N.

ORG: none

TITLE: Quantum electronics research

SOURCE: AN SSSR. Vestnik, no. 6, 1965, 101-102

TOPIC TAGS: quantum electronics, electronic conference, laser, semiconductor laser, laser optics

ABSTRACT: A session of the Department of General and Applied Physics of the Physics Institute im. P. N. Lebedev, Academy of Sciences USSR, held in the Soviet Union on 17-18 March 1965 was devoted to quantum electronics and microwave propagation. The lectures on quantum electronics were concerned exclusively with results of research conducted in the laboratory of N. G. Basov, Corresponding Member of the Academy of Sciences.

The lecture by O. N. Krokhin dealt with high-intensity lasers and their applications in physics. The very high field intensities (10^7—10^8 v/cm) and high concentration of energy in the light wave which can be achieved

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ACC NR: AP5015833

with such lasers make it possible to investigate nonlinear effects and the effects of thermal interaction with various materials. Krokhin described his research with an 8-j laser (10^{-8} sec pulse duration) in heating various substances at a focal point of the optical system. The energy density in such experiments was greater than 3×10^{12} w/cm^2 and the temperatures attained were 100,000—200,000K.

O. V. Bogdankevich described the state of the art of electron-beam-pumped semiconductor lasers, pointing out that fabrication of such lasers helped to expand the wavelength range for laser action (the range now extends from 0.5 to 5.5μ). The efficiency of such lasers is about 7% and their output is several kilowatts per pulse. Electron-beam-pumped lasers have much greater power output potential and their coherence can be made to approach that of lasers fabricated from various crystals.

A. Z. Grasyuk discussed optically excited semiconductor lasers from the standpoint of high-efficiency conversion of noncoherent radiation into coherent radiation. Present optically pumped semiconductor lasers have an efficiency of about 4% and a power output of up to 10 kilowatts. The thickness of the active area responsible for laser action has been increased to 1 mm. Grasyuk also discussed some results on the nonlinear absorption of light in semiconductors.

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L 5270-66
ACC NR: AP5015833

A. N. Orayevskiy presented a theoretical analysis of multimode oscillations (taking phase relationships into account) and obtained theoretically an unattenuated regime with a time-modulated amplitude similar to the spikes observed in laser emission. G. M. Strakhovskiy described a method in which a hydrogen beam laser is used for determining the relaxation rates of active molecules. [FSB: v. 1, no. 12]

SUB CODE: EC, OP / SUBM DATE: none

Card 3/3

L 2330-66 EWA(k)/FBD/EWT(1)/EEC(k)-2/T/EWP(k)/EWA(m)-2/EWA(h) SCTB/IJP(c)
ACCESSION NR: AP5022695 WO/AT UR/0181/65/007/009/2612/2619

61
58
B

AUTHOR: Krokhin, O. N. 44,55

TITLE: The amplification coefficient and the saturation effect in homogeneously excited semiconductors 21, 44,55

SOURCE: Fizika tverdogo tela, v. 7, no. 9, 1965, 2612-2619

TOPIC TAGS: laser, semiconductor laser, stimulated emission, population inversion, amplification, absorption coefficient 25,44

ABSTRACT: An attempt is made to determine the most important effects determining the properties of the emission line and, therefore, the coefficient of absorption, and to establish approximate relationships for simplifying the further analysis of the operating regime of homogeneously excited semiconductor lasers. Homogeneous excitation applies to lasers with active regions the thickness of which exceeds considerably the wavelength of the emitted radiation, i.e., to electron-beam-pumped lasers and lasers excited with photons with an energy exceeding the width of the forbidden gap. In the case of direct transitions, a formula is derived for the amplification coefficient which is then used to obtain the oscillation criteria for such lasers, i.e., for the threshold value of the sum of the quasi-Fermi levels of elec-

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L 2330-66
ACCESSION NR: AP5022695 3

trons and holes. Rate equations are used in an analysis of the saturation effect. The electrodynamic analysis of systems considered in this paper differs considerably from that for a two-level laser, due to the uniqueness of the relaxation processes in semiconductors with wide energy bands and broad emission lines of the order of kT. Orig. art. has: 26 formulas. [CS]

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva, Moscow (Physics Institute) 44,55

SUBMITTED: 20Feb65 ENCL: 00 SUB CODE: EC,SS

NO REF SOV: 006 OTHER: 005 ATD PRESS: 4107

Card 2/2

L 18721-66 FBD/EWT(1)/EEC(k)-2/T/EWP(k)/EWA(h) IJP(c) WG

ACC NR: AP6006839 SOURCE CODE: UR/0181/66/008/002/0511/0514

AUTHOR: Krokhin, O. N.; Uspenskiy, A. V.

ORG: Physics Institute im. P. N. Lebedev AN SSSR, Moscow (Fizicheskiy institut AN SSSR)

TITLE: Asymmetry in the excitation of oscillation modes in semiconductor lasers

SOURCE: Fizika tverdogo tela, v. 8, no. 2, 1966, 511-514 25,44 48 46 P

TOPIC TAGS: laser theory, semiconductor laser, laser

ABSTRACT: The authors study the excitation of axial modes in semiconductor lasers. It is assumed that both the amplification factor and its spectral form are functions of the degree of inversion in the semiconductor. The case of direct interband transitions in a uniformly excited semiconductor laser is studied. The analysis is based on rate equations for the chemical potentials of the carriers and the number of photons. It is shown that the relationship between the amplification factor and the degree of inversion (the shift in the maximum and the change in form) results in asymmetric excitation of axial modes. This excitation is weakly asymmetric when

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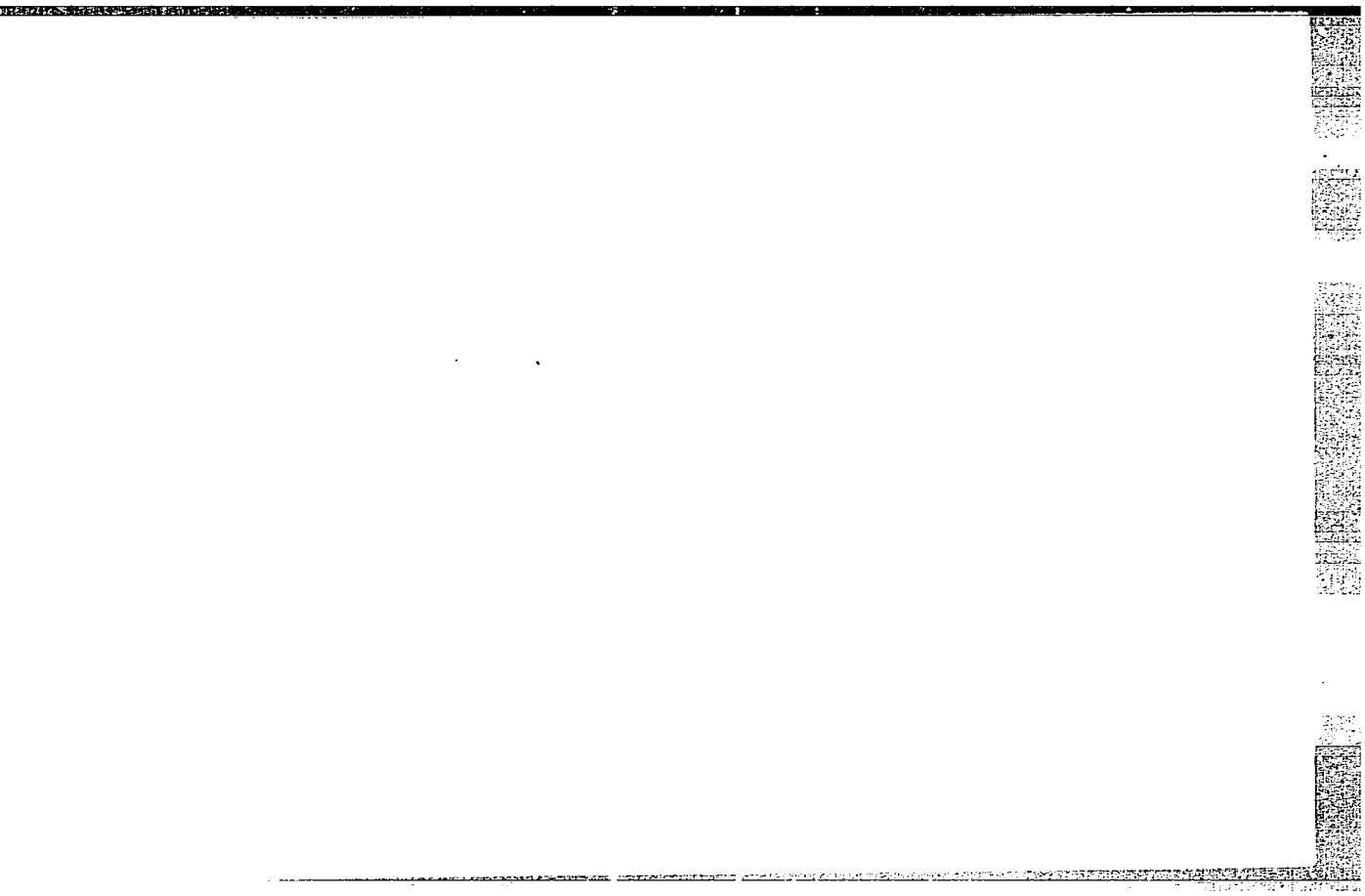
L 18721-66
ACC NR: AP6006839

emission begins far from the edge of the band, while excitation is totally asymmetric when the first mode is excited so close to the edge of the band that the frequency of the next longer mode is located beneath the edge and excitation cannot occur. "In conclusion the authors thank N. G. Basov and P. G. Yeliseyev for discussing the results and for valuable comments." Orig. art. has: 8 formulas. [14]

SUB CODE: 20/ SUBM DATE: 15Jun65/ ORIG REF: 001/ OTH REF: 002/ ATD PRESS: 4217

Card 2/2



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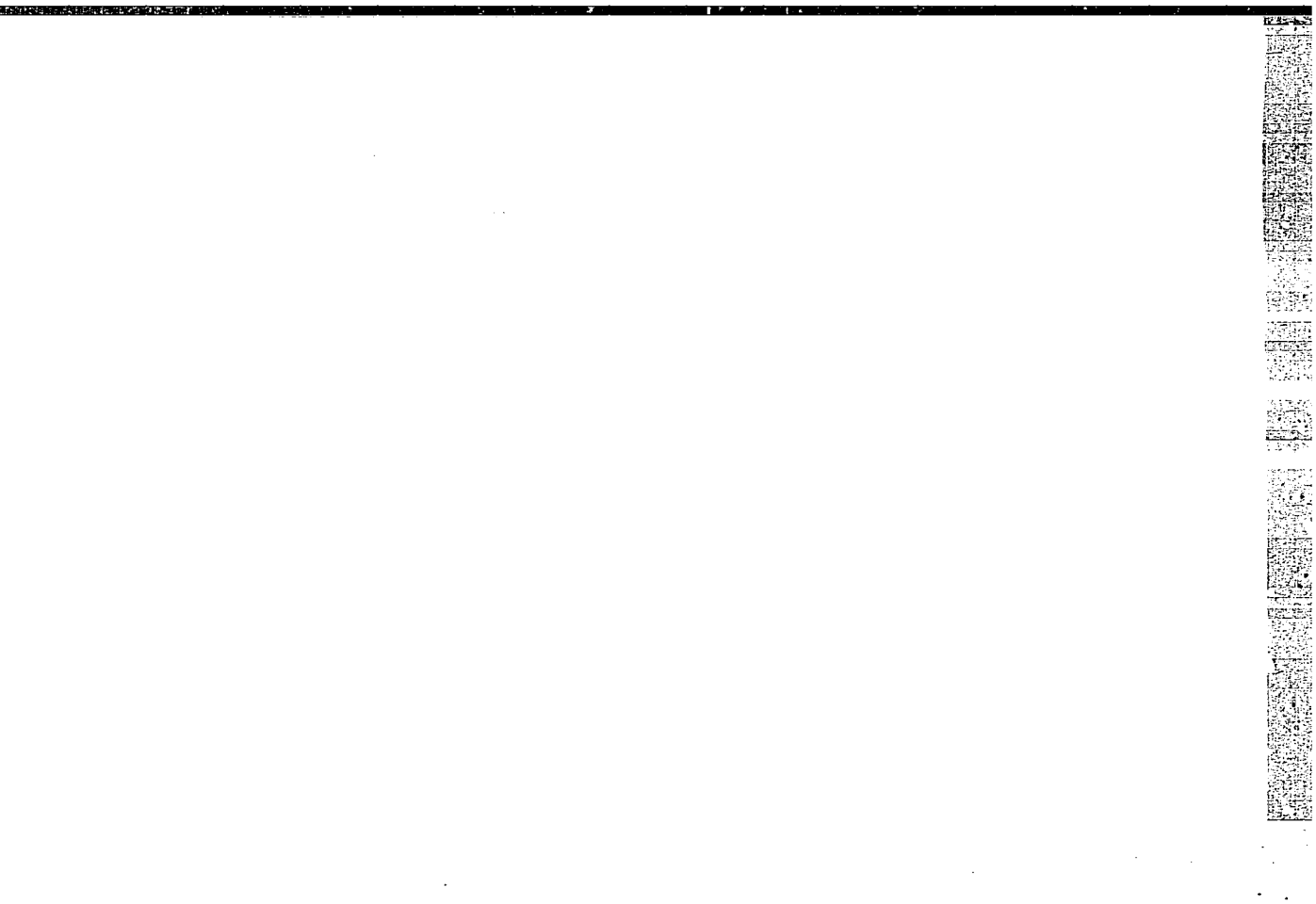

L 22769-66 EWD/EWT(1)/EEC(k)-2/T/EWP(k)/EWA(h) IJP(c) WG

ACC NR: AP6010975 SOURCE CODE: UR/0056/66/050/003/0551/0559

AUTHOR: Basov, N. G.; Grasyuk, A. Z.; Zubarev, I. G.; Katulin, V. A.; Krokhin, O. N.

ORG: Physics Institute im. P. N. Lebedev, Academy of Sciences SSSR (Fizicheskiy institut Akademii nauk SSSR)

TITLE: Two-photon optically excited semiconductor laser

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 50, no. 3, 1966, 551-559

TOPIC TAGS: laser, semiconductor laser, nonlinear optics, two photon absorption, optical excitation

ABSTRACT: The present paper is an expanded version of an earlier article on a two-photon optically excited GaAs laser (Zhurnal eksperimental'noy i teoreticheskoy fiziki, pis'ma v redaktsiyu, v. 1, no. 4, 1965, p. 29; (see ATD PRESS, v. 4, no. 15, 1965, p. 9)). It is pointed out that in calculating the coefficients of two-photon absorption in CdC, R. Braunstein and N. Ockman (Physical Review, v. 134, no. 2A, 1964, p. 499) neglected the interband states in the valence band and the interference turn in the matrix elements, and thus arrived at incorrect results. Since a formula derived by L. V. Keldysh (Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 47, 1964, p. 1945) for the probability of multiphoton absorption gives a lower value than the experimentally obtained data for two-photon absorption, formulas are derived for the probability and the coefficient of two-photon absorption in GaAs, using the perturba-

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L 22769-66
ACC NR: AP6010975 O

tion theory and taking into account the band structure parameters of GaAs. In addition, expressions are also obtained for the dependence of the excitation intensity on the penetration depth of the exciting radiation into the semiconductor and the external coherent quantum yield and its dependence on the internal losses in the laser and on the length of the cavity. The calculated data are found to be in good agreement with the experimental results. Orig. art. has: 18 formulas and 7 figures. [CS]

SUB CODE: 20/ SUBM DATE: 060ct65/ ORIG REF: 007/ OTH REF: 004/ ATD PRESS: 4229

Card 2/2 dda

ACC NR: AP6036047 SOURCE CODE: UR/0056/66/051/004/0989/1000

AUTHOR: Basov, V. A.; Dement'yev, V. A.; Krokhin, O. N.; Sklizkov, G. V.

ORG: Physics Institute im. P. N. Lebedev, Academy of Sciences SSSR (Fizicheskiy institut Akademii nauk SSSR)

TITLE: Heating and decay of a plasma produced by a giant laser pulse focused on a solid target

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 51, no. 4, 1966, 989-1000

TOPIC TAGS: ~~giant pulse laser~~, plasma decay, plasma diagnostics, laser application, laser plasma

ABSTRACT: The authors obtain the distribution of the fundamental gas dynamics parameters of the plasma produced by a giant laser pulse focused on a solid target carbon surface during its early decay stages. The plasma was investigated with apparatus having a high time resolution permitting the radii of various regions of the flare to be determined as functions of the time. The experiments consisted of recording the charged-particle flow to a shielded probe (Fig. 1), the giant pulse being produced by a neodymium-glass laser described elsewhere (ZhETF Pis'ma v. 2, 57, 1965). The motion of the luminous plasma boundary was investigated by high-speed photography with SFR-2M equipment at a time resolution of 1.5 nsec. The motion of the internal region of the flare was fol-

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ACC NR: AP6036047

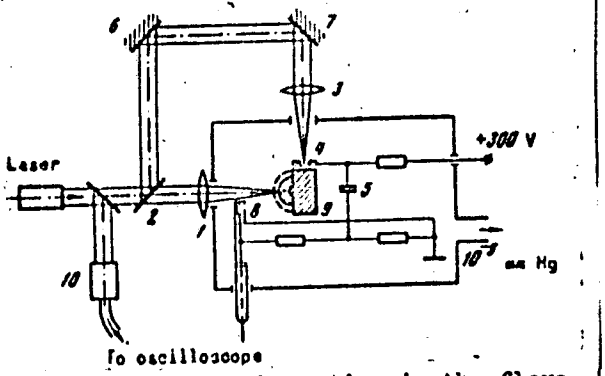

Fig. 1. Experimental setup for the determination of the R-t diagrams of the neutral boundary of the flare. 1 - Lens, 2 - semitransparent mirror, 3 - lens, 4 - discharge gap, 5 - capacitor, 6, 7 - mirrors, 8 - probe, 9 - target.

lowed by a shadow method with light from a laser pulse. The absorption in the flare was determined indirectly by measuring the transmission coefficient, and the density and temperature distributions in the flare were estimated from the measurement results as function of the laser power. A theoretical interpretation is proposed for the evolution of the heat rise and motion of the flare, based on the simplifying assumption that the problem has spherical symmetry and that the velocity varies linearly with the radius. The proposed theory is found to be in qualitative agreement with the experimental data. The authors thank V. S. Zuyev for collaborating in the experiments. Orig. art. has: 10 figures and 15 formulas.

SUB CODE: 20/ SUBM DATE: 21Mar66/ ORIG REF: 010/ OTH REF: 007/ ATD PRESS: 5106

Card 2/2

ACC NR: AP7001995 SOURCE CODE: UR/0040/66/030/006/1022/1028

AUTHOR: Afanas'yev, Yu. V. (Moscow); Krol', V. M. (Moscow); Krokhin, O. N. (Moscow); Nemchinov, I. V. (Moscow)

ORG: Institute of Physics of the Earth, AN SSSR (Institut fiziki Zemli AN SSSR); Physics Institute, AN SSSR (Fizicheskiy institut AN SSSR)

TITLE: Gas dynamic processes during the heating of matter by means of a laser beam

SOURCE: Prikladnaya matematika i mekhanika, v. 30, no. 6, 1966, 1022-1028

TOPIC TAGS: laser radiation, radiative heating, thermodynamic process

ABSTRACT:

An investigation was made of the heating process and the gas dynamic motion of matter subjected to the effects of a powerful laser beam. An examination was made of the case when a bounded transparent mass of gas was heated. The problem of the heating of an initially cold and motionless gas, filling a space bounded by a vacuum, was also solved. The gas dynamic approach for solving these problems was selected because at sufficiently powerful fluxes of laser radiation the rise in temperature is accompanied by the formation of gas dynamic motion of matter (evaporation), which itself exerts a substantial effect on the whole process of heating. One of the features of the process which complicates solution of the prob-

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ACC NR: AP7001995

lem is the dependence of the absorptive power on the state of matter during its gas dynamic motion. On the basis of a system of equations for motion, continuity, energy, and radiation transfer, expressed in Lagrange coordinates, a system of differential equations was derived. The existence of self-similar motion was shown. The results of the self-similar solution and of the numerical calculations were obtained and compared. A study was made of the possibility of employing the results obtained to describe the heating and evaporation of matter from the surface of a solid body under the effect of a Q-switched laser beam. The authors thank N. G. Basov, S. P. Kurdyumov, and A. A. Milyutin for discussing the problem and for their advice, and V. V. Novikova for her help in the numerical calculations. Orig. art. has: 14 formulas and 5 figures.

SUB CODE: 20/ SUBM DATE: 24Mar66/ ORIG REF: 004/ OTH REF: 001/ ATD PRESS: 5111

Card 2/2

KROKHIN, S., mekhanik-nastavnik

A diving station on a ship bottom cleaning crane. Rech.transp. 23 no.11:48-49 N '64. (MIRA 18:3)

1. Volzhskoye basseynovoye upravleniye puti.

1. KROKHIN, S. A., Eng.

2. USSR (600)

4. Concrete Consturction - TSimlyansk Hydro-Electric Power Station

7. Repair of equipment in automatic concrete plants at the construction site of the TSimliansk hydroelectric power development. Mekh.stroi., 9, no. 12, 1952.

9. Monthly List of Russian Accessions, Library of Congress, April 1953, Uncl.

ALEKSEYEV, G.P.; ANDON'YEV, V.S.; ARNGOL'D, A.V.; BASKIN, S.M.; BASHMAKOV, N.A.; BEREZIN, V.D.; BERMAN, V.A.; BIYANOV, T.F.; GORBACHEV, V.N.; GRECHKO, I.A.; GRINBUKH, G.S.; GROMOV, M.F.; GUSEV, A.I.; DEMENT'YEV, N.S.; DMITRIYEV, V.P.; DUL'KIN, V.Ya.; ZVANSKIY, M.I.; ZENKEVICH, D.K.; IVANOV, B.V.; INYAKIN, A.Ya.; ISAYENKO, P.I.; KIPRIYANOV, I.A.; KITASHOV, I.S.; KOZHEVNIKOV, N.N.; KORMYAGIN, B.V.; KROKHIN, S.A.; KUDOYAROV, L.I.; KUDRYAVTSEV, G.N.; LARIN, S.G.; LEBEDEV , V.P.; LEVCHENKOV, P.N.; LEMZIKOV, A.K.; LIPGART, B.K.; LOPAREV, A.T.; MALYGIN, G.F.; MILOVIDOVA, S.A.; MIRONOV, P.I.; MIKHAYLOV, B.V., kand. tekhn. nauk; MUSTAFIN, Kh.Sh., kand. tekhn. nauk; NAZIMOV, A.D.; NEFEDOV, D.Ye.; NIKIFOROV, I.V.; NIKULIN, I.A.; OKOROCHKOV, V.P.; PAVLENKO, I.M.; PODROBINNIK, G.M.; POLYAKOV, G.Ya.; PUTILIN, V.S.; RUDNIK, A.G.; RUMYANTSEV, Yu.S.; SAZONOV, N.N.; SAZONOV, N.F.; SAULIDI, I.P.; SDOBNIKOV, D.V.; SEMENOV, N.A.; SKRIPCHINSKIY, I.I.; SOKOLOV, N.F.; STEPANOV, P.P.; TARAKANOV, V.S.; TREGUBOV, A.I.; TRIGER, N.L.; TROITSKIY, A.D.; FOKIN, F.F.; TSAREV, B.F.; TSETSULIN, N.A.; CHUBOV, V.Ye., kand. tekhn. nauk; ENGEL', F.F.; YUROVSKIY, Ya.G.; YAKUBOVSKIY, B.Ya., prof.; YASTREBOV, M.P.; KAMZIN, I.V., prof., glav. red.; MALYSHEV, N.A., zam. glav. red.; MEL'NIKOV, A.M., zam. glav. red.; RAZIN, N.V., zam. glav. red. i red. toma; VARPAKHOVICH, A.F., red.; PETROV, G.D., red.; SARKISOV, M.A., prof., red.; SARUKHANOV, G.L., red.; SEVAST'YANOV, V.I., red.; SMIRNOV, K.I., red.; GOTMAN, T.P., red.; BUL'DYAYEV, N.A., tekhn. red.

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ALEKSEYEV, G.P.---(continued). Card 2.

[Volga Hydroelectric Power Station; a technical report on the design and construction of the Volga Hydroelectric Power Station (Lenin), 1950-1958] Volzhskaia gidroelektrostantsiia; tekhnicheskii otchet o proektirovanii i stroitel'stve Volzhskoi GES imeni V.I.Lenina, 1950-1958 gg. V dvukh tomakh. Moskva, Gosenergoizdat. Vol.2.[Organization and execution of construtions and assembly work] Organizatsiia i proizvodstvo stroitel'no-montazhnykh rabot. Red. toma: N.V.Razin, A.V.Arngol'd, N.L. Triger. 1962. 591 p. (MIRA 16:2)

1. Deystvitel'nyy chlen Akademii stroitel'stva i arkhitektury SSSR (for Razin).
(Volga Hydroelectric Power Station (Lenin)--Design and construction)